SECTION 1

LIVING WITH WILDLAND FIRE IN THE URBAN ENVIRONMENT

INTRODUCTION

The extraordinary natural, climatic, and geographic diversity of the United States exposes the Nation to a wide range of natural hazards. Additionally, increased population densities and property development in hazard zones have dramatically heightened the Nation's disaster vulnerability. It has been estimated that weather and climate events have up to a $2.2 trillion impact on the U.S. economy annually. Conservative estimates of the comprehensive disaster costs, related to the annual loss of life and property, disruption of commerce, and response and recovery, are at least $20 billion.

The sheer diversity of the hazards and their weather-related determinants pose an additional challenge for urban meteorology. The Office of the Federal Coordinator for Meteorological Services and Supporting Research (commonly known as OFCM), in partnership with the Department of Homeland Security (DHS) Science and Technology Directorate, conducted a User Forum on Urban Meteorology, September 21-23, 2004. During the forum, hazards in five areas of the urban environment were identified: severe weather, homeland security (emergency response to airborne hazards), air and water quality, and climate-related conditions.

Wildland fire is a hazard whose impacts crosscut the aforementioned five hazard areas of the urban environment. As will be discussed later in this paper, severe weather phenomena can cause wildland fire (i.e., thunderstorms) or increase the risk of wildland fire (i.e., strong winds). Wildland fire poses a great threat to life and property and can result in a number of potential urban environmental impacts, including increased urban air pollution and health impacts due to smoke particles, possible degraded water quality through the release of burned debris into public water sources, and hampered local transportation, both on the ground and in the air, thereby affecting public safety and commerce. Climate also plays an important role in the wildland fire hazard (e.g., areas experiencing climate-induced drought conditions may be at increased risk for wildland fires).

The past several decades have seen an increase in population growth in formerly rural areas. For example, many areas in California, Florida, and Texas have seen up to a 30 percent increase in population during the period 2000-2003 (Figure 1-1). This increase has moved more people into an expanding urban environment (i.e., the urban "sprawl" has spread into areas where forests and natural landscapes used to exist). The area where structures and/or other human development meet or intertwine with undeveloped wildland or other forms of vegetative fuels is often referred to as the wildland /urban interface.

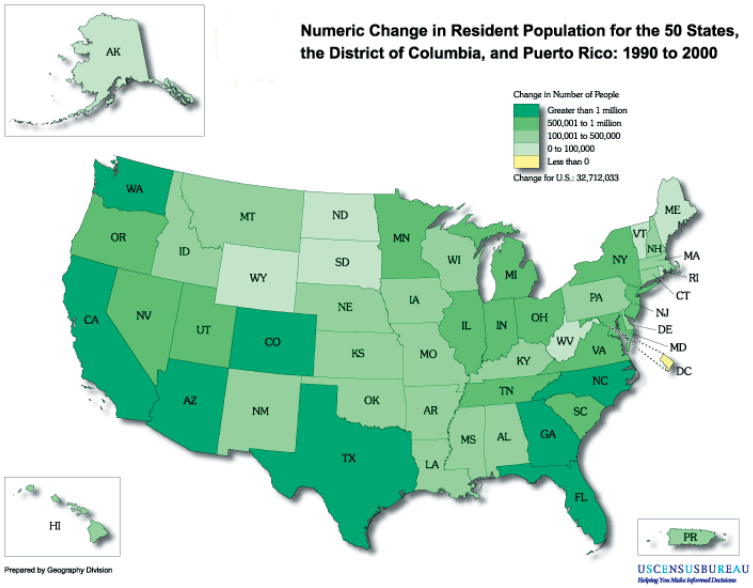

Figure 1-1. Population increases to the coastal/urban areas, 1990-2000. (U.S. Census Bureau)

Some examples of these wildland fires which have affected the urban environment include the Oakland Hills, California fire in October 1991 (Figure 1-2) with 25 lives lost and 2,900 structures destroyed; the Cerro Grande, New Mexico fire in May 2000 where 235 structures were destroyed and the Los Alamos National Laboratory was damaged; and, more recently, the wildland fires in Southern California which claimed 22 lives, destroyed 3,600 homes, burned nearly 740,000 acres of land, and caused more than $2 billion in property damage. During an average year, nearly 70,000 wildfires burn approximately 4.5 million acres.

The impacts of hazard events such as wildland fires can be mitigated through careful planning and by taking appropriate actions. Communities across the Nation can be better prepared to withstand hazard events through improved research; improved data collection,

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Figure 1-2. A devastating fire occurred in the hills above Oakland and Berkeley, California, on October 20, 1991 (the Oakland Hills fire).

analysis, data assimilation, prediction, and interpretation; improved hazard preparedness and response; and effective public education and warning. It is important to keep in mind that wildland fire is a natural part of the environment for most of the country. While detrimental impacts of fire can be minimized, humans must also learn to live with fire.

This article summarizes the causes of wildland fires, presents a description of the impact wildland fire has on urban communities, reviews some activities undertaken by Federal agencies to minimize the impacts, and provides some recommended next steps to address the spectrum of wildland fire impacts.

Code	USFS	DOI
01	Lightning	Lightning
02	Aircraft	Aircraft
03	Burning vehicle	Vehicle
04	Exhaust-power saw	Exhaust – power saw
05	Exhaust-other	Exhaust – other
06	Logging line	Logging line
07	Brakeshoe	Brakes
08	Cooking fire	Cooking fire
09	Warming fire	Warming fire
10	Smoking	Smoking
11	Trash burning	Trash burning
12	Burning dump	Burning dump
13	Field burning	Field burning
14	Land clearing	Land clearing
15	Slash burning	Slash burning
16	Right-of-way burning	Right-of-way burning
17	Resource management burning	Resource management burning
18	Grudge fire	Grudge fire
19	Pyromania	Recurrent
20	Smoking out bees or game	Smoke out bees/game
21	Insect/snake control	Insect/snake control
22	Job fire	Employment
23	Blasting	Blasting
24	Burning building	Burning building
25	Power line	Power line
26	Fireworks	Fireworks
27	Playing with matches	Ignition devices
28	Repel predatory animals	Repel predators
29	Stove fuel sparks	House/stove flue sparks
30	Other	Other (unknown)
31		Volcanic
32		Other (known)

Table 1.1. Specific causes of wildland fires as defined by USFS and DOI. (Brown et al., 2002)

CAUSES OF WILDLAND FIRES

The causes of wildland fire fall into two distinct categories: human and natural. To understand the impact of wildland fire, one needs to determine the causes to be able to predict high-risk areas for fires, to develop fire-management tools, and to predict the seasonal variations which contribute to fire development.

The public may not be aware of all the possible ways they contribute to the human-generated wildland fires. Human-caused ignitions include those from equipment exhaust, abandoned campfires, cigarettes, and arson. Table 1.1 lists the various sources of wildland fires.

Though ultimately a very small percentage, fires deliberately started for fuels management have resulted in a wildland fire. The Cerro Grande fire in May 2000 is one recent example of a prescribed fire which turned into a wildland fire, enhanced by adverse weather conditions. The fire resulted in over 200 destroyed structures, damage to the Los Alamos National Laboratory, and the evacuation of 18,000 residents. In the period from 1968-2000, 38 of 3,746 prescribed fires went out of control.

Prescribed fire: Any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and National Environmental Policy Act requirements (where applicable) must be met, prior to ignition.

Wildland fires can also be caused by naturally occurring atmospheric phenomena, specifically lightning from thunderstorms. Lightning-initiated wildland fires account for 80 percent of the overall fires in the western United States (Figure 1-3). Climatic events such as El Nino and weather phenomena such as prolonged heat waves can lead to fire-prone areas where fires are easily sustained with dry fuels.

The El Nino weather pattern of 1997-1998 disrupted rainfall patterns, leaving many forests dry. Thousands of deliberately set forest fires, mainly for cultivation, raged out of control in Indonesia, Brazil, and Mexico, burning millions of hectares of rain forest. Thick clouds of smoke blanketed vast areas in Southeast Asia, South America, and Central America, sending tens of thousands of people to hospitals with respiratory illnesses related to the polluted air.

The causes of most wildland fires are known, but not everybody realizes the extent of the impacts wildland fire can have on the urban environment.

POTENTIAL IMPACTS OF WILDLAND FIRES

There are several direct impacts of wildland fires. These impacts include: the loss of life and property; air quality and health problems; affects on transportation, both air and ground; impacts on our forest and rangeland ecosystems, water systems, and wildlife; and impacts on national and local economies.

The greatest impact of wildland fires is the loss of life, both within the firefighting community and the general public. Over the last 100 years, 918 firefighters have lost their lives in wildfires. In 1918, the Moose Lake Fire in Minnesota resulted in a total of 450 lives lost. Second to loss of life is

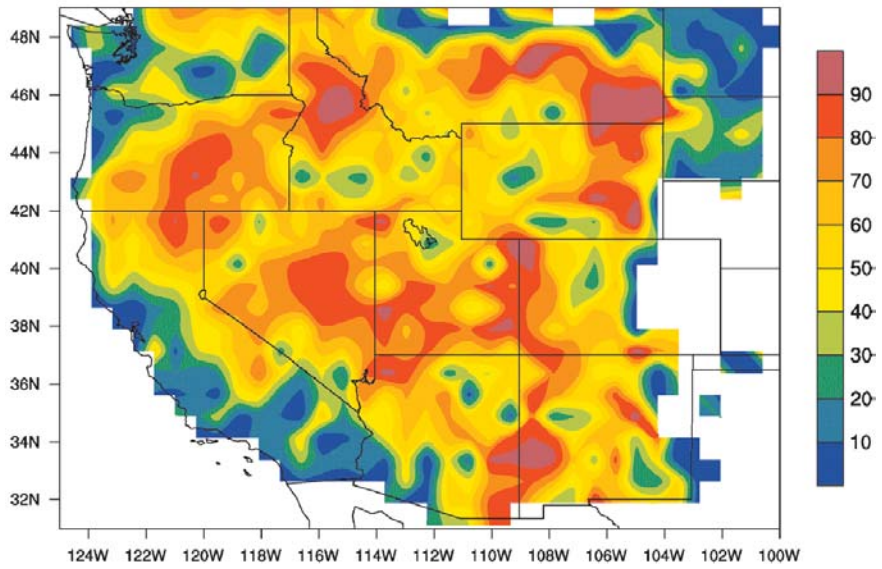

Figure 1-3. Percent of coarse quality controlled western U.S. Federal wildland fires caused by lightning for the period 1970-2000. (http://www.cefa.dri.edu/Publications/fireoccurrencereport.pdf - Figure 11)

the loss of personal property. In the San Diego County fires, 3,600 homes were destroyed, causing upwards of $2 billion dollars in damage, not to mention the displacement of those families. In 2003, natural catastrophes caused insured losses of $15 billion (USD) across the globe. During that period, two wildland fires resulted in losses of $2.1 billion dollars and 18 victims (dead and missing).


Figure 1-4. Smoke from fires in California, October 2003, as seen from space. At least 22 deaths were blamed on the wildfires. (Image courtesy of NASA)

Smoke from wildland fires in the urban environment can impact air quality and create health issues (Figure 1-4). Smoke can irritate the eyes and respiratory system and worsen chronic heart and lung diseases. The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS), together with the Environmental Protection Agency (EPA) and other local air quality offices, issues air stagnation advisories, instructing the public of the potential health impacts and actions to take, such as avoiding outdoor activity and remaining indoors whenever possible during hazardous situations. One personal example occurred during the 2003 fires in San Diego, California. Cemetery workers were required to stay at home due to the smoke, postponing a family funeral for several days.

Wildland fires can impact both surface and aviation transportation. In 1994, a major interstate through Colorado was closed as the fire burned alongside the hillside next to the pavement. In 2002, the interstate mountain pass between Sacramento, California, and Reno, Nevada, was closed for over a day as the fire "jumped" across the interstate. Air transportation is impacted from smoke plumes or smoke reducing visibilities near major airports. Under these conditions, commercial airlines may be forced to reroute or cancel flights, impacting the Nation's air travel, not to mention the economic impact on the airlines.

One of the more complex issues to understand is the impact wildland fire has on our ecosystems, which includes our forests, rangelands, water systems, and wildlife. Wildland fire can destroy the environment of animals and endangered species (both plant and animal) and eliminate source areas of rich carbon dioxide needed for the balance of our atmosphere. Wildland fire also can directly impact our water supplies. One example is the impact of heavy rains in steep terrain that surrounds a watershed after the steep terrain has been burned by a wildfire. Sediments from burned areas can wash down into rivers that serve as the primary water sources for cities.

Ecosystem: a functional unit consisting of all the living organisms (plants, animals, and microbes) in a given area, and all the non-living physical and chemical factors of their environment, linked together through nutrient cycling and energy flow. An ecosystem can be of any size-a log, pond, field, forest, or the earth's biosphere-but it always functions as a whole unit. Ecosystems are commonly described according to the major type of vegetation, for example, forest ecosystem, old-growth ecosystem, or range ecosystem.

The Buffalo Creek Fire in Colorado in May of 1996 was followed by substantial flooding and erosion 2 months later. The fire burned 12,350 acres. The flooding after the fire killed two people and, in the 3 months following the fire, transported approximately 331,000 m^3 of coarse sediment into the Strontia Springs Reservoir. This reservoir supplies over 75 percent of the drinking water to the city of Den-

ver and experienced a significant degradation in water quality as a result of the input of burned material and sediment. The Denver Water Department, the agency responsible for distributing drinking water from the reservoir, estimates that it spent over $1 million in immediate clean-up efforts after the fire.

Wildland fires also directly impact the economy due to large fire suppression costs. Severe fire seasons due to drought can result in billions of dollars in damages. The Western fire season, spring-summer 2000, resulted in nearly seven million acres burned and an estimated $2 billion in damage costs (including fire suppression). In fiscal year 2005, the U.S. Department of Agriculture Forest Service (USDA-FS) total fire operations budget was slightly over $1 billion; approximately $300 million of this was designated to hazardous fuel reduction. This does not include the costs incurred by the U.S. Department of Interior (DOI) land management agencies, state agencies, and private sector. Typically, prescribed fire costs range from approximately $70 to $150 per acre for treatment. Suppression costs, by comparison, range from $500 to $8000 per acre, depending upon the actions required. Over the last decade, 98 percent of wildland fires are extinguished during initial attack, however, 80 percent of wildland fire costs are driven by the 2 percent of wildland fires which grow into large fires. Preventing wildland fires is obviously extremely important, especially human-caused fires. If a wildland fire begins, early detection and quick initial attack actions are also extremely important.

Wildland fires can also have economic impacts on private businesses and industries. Private businesses may be forced to close down or be destroyed by wildland fire. The timber industry can experience a loss of income from unwanted acreage burned prior to harvest, and large areas of state and federal forests can be lost to recreational uses. One industry beginning to be impacted is the insurance industry. Recently, some companies are not renewing homeowner policies if the home does not have the required defensible space surrounding the house. This has led to increasing insurance rates and new government policies, such as increasing the minimum clearance (defensible space) requirements around homes in susceptible areas.

WHAT CAN WE DO?

Wildland fires have direct impacts on the urban environment. The Federal agencies have begun to respond to the need for mitigating the impacts. The capabilities of current weather/climate services and products to address the wildland fire issue are found across the Federal agencies, state and local governments, industry, and universities. The following are a series of probing questions and brief summaries that the Federal community is tackling in order to address the needs of the urban users to further improve the response to the wildland fire issue:

HOW DO WE IMPROVE OBSERVATIONS AND FORECASTS OF WILDLAND FIRE?

There are several programs within NOAA's NWS, the DOI Bureau of Land Management (DOI-BLM), and the USDA-FS for the data collection, analysis, assimilation, and prediction of wildland fires. There are over 2,200 interagency Remote Automated Weather Stations (RAWS) strategically located throughout the United States. These data are used by NOAA's NWS forecasters to analyze real-time weather conditions, by fire managers to predict fire behavior and monitor fuels, and by resource managers to monitor environmental conditions. The data are also used to monitor air quality and for research studies. Data are collected at the National Interagency Fire Center (NIFC) in Boise, Idaho, via NOAA's Geostationary Operational Environmental Satellite.

NOAA's NWS supports the wildland fire community daily through the provision of forecast products and services. The importance NWS places on these services results from a recognition that decades of fuel accumulation in our Nation's forests, coupled with drought, presents our state and federal fire management partners with larger, more explosive, and more costly wildland fires than any other period in history. NWS also recognizes that the fire management agencies in the United States have begun moving aggressively to deal with these issues through the efficient management of wildland fires and the implementation of prescribed burning programs.

To manage and suppress wildfires, including prescribed fires, fire managers need current and forecast weather and climate services. For instance, if a wildland fire starts due to lightning from thunderstorms, early detection and quick initial attack actions are extremely important to minimize suppression costs and prevent loss of property and lives. Therefore, accurate forecasts of thunderstorm activity and wind direction/speed enhance the fire manager's ability to detect fires, know where to enhance fire surveillance, and respond to the event. The NWS provides continued support to fire managers through their fire weather program which includes the following:

- Daily issuance of our Fire Weather Planning Forecasts, detailing daily forecasts of temperature, wind, humidity, dispersion, and other locally critical parameters.
- Provision of Fire Weather Watches and Red Flag Warnings for critical weather events that impact firefighter safety and preparedness.
- Issuance of Spot Forecasts - site-specific weather for fire managers.

• Incident Meteorologist (IMET) support-a cadre of over 60 specially trained forecasters who work directly with Incident Management Teams.

The DOI-BLM also provides prediction and modeling services. The Predictive Services units reside at the National Interagency Coordination Centers throughout the United States. These units provide decision-support information needed to implement a more proactive approach to anticipating fire activity through the prepositioning and integration of fire weather, fire danger/fuels information, and intelligence resources. In 2000, 20 fire weather meteorologists were hired under the National Fire Plan to team up with intelligence specialists and wildland fire analysts to form Predictive Service units at the National Interagency Coordination Center (NICC) and the Geographic Area Coordination Centers (GACC).

The interagency coordination centers' primary mission is to provide resource support for the functional areas of overhead, crews, aircraft, supplies, and equipment to the field for wildland fire and other emergency operations. They also provide daily, medium-range, and long-range fire-weather, fire-danger, and resource outlooks for use in tactical and strategic planning.

The USDA-FS Fire Consortia for the Advanced Modeling of Meteorology and Smoke (FCAMMS) is a Forest Service research and development initiative that uses high technology for computing, advanced numerical weather prediction models, World Wide Web information delivery, and new sources of information, such as the NASA Terra and Aqua satellites, in a new business partnership framework for advancing fire practice and science. These partnerships include not only federal and state agencies, but also universities (e.g., Washington State University and Jackson State University) and private industry (e.g., Sun Microsystems, Inc.). Many of the real-time model predictions are currently available on-line for use by the fire community.

Lastly, the Joint Center for Satellite Data Assimilation (JCSDA) is working towards the acceleration and improvement of the use of research and operational satellite data in weather and climate prediction models. JCSDA includes NOAA (NWS, National Environmental Satellite Data, and Information Service, and the Office of Oceanic and Atmospheric Research), the National Aeronautics and Space Administration (Goddard Space Flight Center), and the Department of Defense (U.S. Navy and U.S. Air Force). Data assimilation improvements will lead towards a more accurate prediction of weather for the user community.

WHAT ADDITIONAL RESEARCH IS NEEDED TO IMPROVE FORECASTS? WHAT ARE THE GAPS IN OUR CAPABILITY?

The Joint Fire Science Program (JFSP) was established in 1998 to provide scientific information and support for wildland fuel and fire management programs. The program is a partnership of six Federal agencies, consisting of the USDA-FS and the following agencies within the DOI: Bureau of Indian Affairs, BLM, National Park Service, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. All JFSP projects require scientist-manager partnerships along with strong emphasis on transferring research findings to the field.

The National Fire Plan (NFP) was developed in August 2000, following a landmark wildland fire season, with the intent of actively responding to severe wildland fires and their impacts on communities, while ensuring sufficient firefighting capacity for the future. The NFP addresses five key points: firefighting, rehabilitation, hazardous fuels reduction, community assistance, and accountability. As it nears its fifth year, the NFP continues to provide invaluable technical, financial, and resource guidance and support for wildland fire management across the United States. Together, the USDA-FS and the DOI are working to successfully implement the key points outlined in the NFP. The program focus is on short-term, applied research that provides information and tools to specialists and managers, helping them make the best possible decisions and develop sound, scientifically valid plans.

Hazard research is being conducted as a response to fire management needs in the areas of atmospheric and fire-behavior modeling. The USDA-FS established five regional modeling consortia in 2000-2001 to support the NFP. Each FCAMMS supports research and operational needs of the members who include land management agencies participating in the NFP, NOAA NWS, the EPA, appropriate state and tribal agencies, universities, and other research partners. High resolution real-time numerical prediction models, as well as smoke-dispersion and fire-behavior models, are being developed.

Despite current research programs on fire weather and the fire environment, additional research and better coordination of existing research is needed.

WHAT IMPROVEMENTS ARE NEEDED TO ENSURE FIRE MANAGERS AND OTHER USERS OF THE INFORMATION (1) RECEIVE THE REQUIRED INFORMATION/ PRODUCTS/FORECASTS AND (2) MAKE THE RIGHT DECISIONS?

Improvements in the ability to detect and predict wildland fire in and around the urban environment will reduce the impact to the loss of life and property. Key to these improvements is to ensure decision makers and the public receive the required information in a timely manner. The most aggressive public

warning program for fires is the NOAA Weather Radio (NWR). The NWR is a nationwide network of radio stations broadcasting continuous weather information direct from a nearby National Weather Service Office. NWR broadcasts NWS warnings, watches, forecasts, and other hazard information 24 hours a day. In addition to the NWR, the communication of warnings to fire managers and the public through partnering agencies, the media outlets (television and radio) and emerging technologies (like cell phones and PDAs) will help create an effective, timely warning system.

One aspect of making the right decision is to receive the required information/ products/forecasts. For instance, having an accurate assessment of the current fire danger is critical information required by decision makers. The USDA-FS National Fire Danger Rating System (NFDRS) "is the keystone of interagency fire danger predictions and provides quantification of risk elements that are critical for daily decisions regarding firefighter resource placement, staffing levels, appropriate suppression responses, and strategic decisions at local, geographical area and national levels." The "Gridded" NFDRS project is a cooperative effort between the Fire Behavior Research Work Unit at the Missoula Fire Sciences Lab and the NOAA NWS Forecast Office in Missoula, Montana. Collaboration continues in efforts to improve this system and its ability to provide fire managers more up-to-date information concerning critical fire-prone areas.

Another example of having the required information/products/forecasts deals with planning actions prior to the fire season. Fire managers who have the responsibility to place limited resources around the country in advance of the fire season or preposition equipment and personnel require forecast information to assist in these decisions. The Climate Ecosystem and Fire Application Program (CEFA) at the Desert Research Institute in Reno, Nevada, along with the National Predictive Services Group, the University of Arizona, and NOAA's Office of Global Programs, conduct yearly workshops for the purpose of creating a "one-voice" seasonal fire outlook (Figure 1-5). The outlooks have begun to provide fire managers with the tools they need for providing quick response to wildland fires.

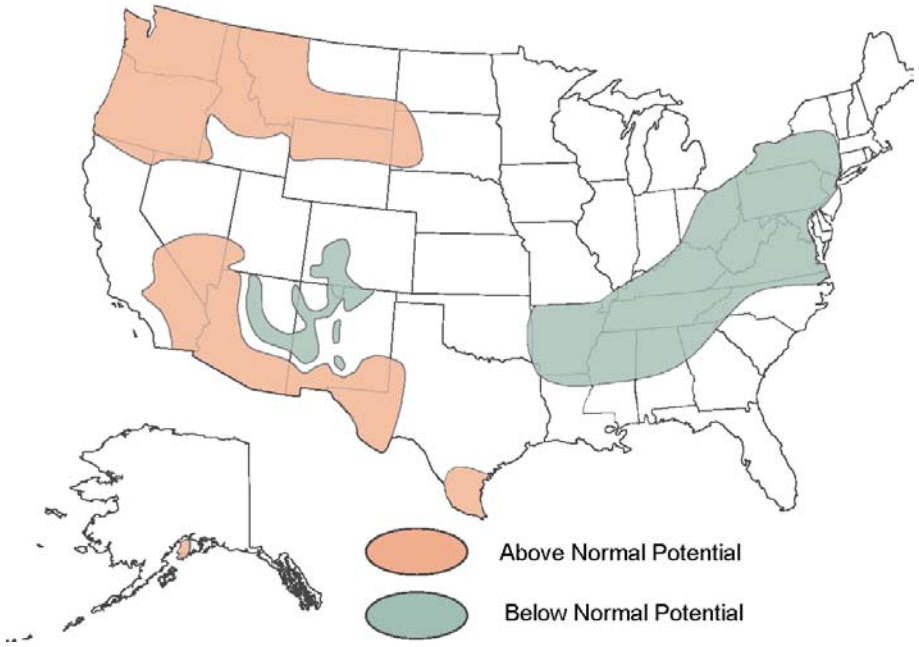

Figure 1-5. The western portion of the map showing the outlook for national significant fire potential was produced during the workshop ending on April 1, 2005. It highlights areas that managers from a variety of geographic areas in the Westconsider to have either above-average or below-average fire potential during the coming season.

After receiving the required information/products/forecasts, a significant factor to ensure the public and users of information make the right decisions is to make certain they have the proper knowledge. To this end, the NIFC Prevention and Education website has an aggressive public awareness program, including public displays, pamphlets, and on-line education materials for a variety of audiences, to include Spanish-speaking personnel. In addition, wildland fire prevention and education teams are available to support any geographic area preceding and during periods of high fire danger or fire activity, with the purpose of assisting the local unit in the prevention of unwanted human-caused wildfires.

Several agencies are also conducting public awareness programs. California has a Fire Safe Council, with over 50 public and private organizations formed to speak with one voice about fire safety. The council has distributed fire prevention education materials to industry leaders and their constituents, evaluated legislation pertaining to fire safety, and empowered grassroots organizations to spearhead the fire safety program. Members include, in addition to state and Federal agencies, the American Red Cross, insurance companies, and realtor organizations. "Firewise" is an education information program for people who live or vacation in fire-prone areas of the United States. Information is supplied and approved by the National Wildfire Coordinating Group, a consortium of

wildland fire agencies that includes the USDA-FS, the DOI, the National Association of State Foresters, the U.S. Fire Administration, and the National Fire Protection Association. "Firewise" is sponsored by the National Wildland/Urban Interface Fire Program.

SUMMARY AND THE WAY AHEAD

Clearly there is a need for the Federal agencies to work towards minimizing the impact of wildland fires in the urban environment, both from a public safety and economic standpoint. The efforts of the Federal agencies to address the spectrum of wildland fire impacts will require the following:

- Continued improvement of fire weather observations and forecasts.
- Improved coordination of wildland fire research and the integration of fire weather and fire environment research.
- A comprehensive National wildland fire weather needs assessment to document user needs/requirements for weather information by decision makers in their wildfire and prescribed fire decision-making processes and a framework to meet those needs.
- Increased efforts to provide education and training on new products and services to ensure the information being delivered is understandable and meets the needs of decision makers and the general public.

REFERENCES

1. http://www.marion.ohio-state.edu/fac/schul/400/0003popchg.png
2. http://www.nifc.gov/stats/index.html
3. Cerro Grande Prescribed Fire Investigative Report, National Park Service, USDOI
4. USDOC/NOAA/NWS Service Assessment "Southern California Wildfires October 20 to November 3, 2003"
5. http://www.firewise.org/pubs/theOaklandBerkeleyHillsFire/)
6. Los Alamos Fire Turns Attention to Burns", June 200, The Forestry Source, Society of American Foresters.
7. National Fire Plan at http://www.fireplan.gov/overview/whatis.html#
8. http://www.cefa.dri.edu/Publications/fireoccurrencereport.pdf -- Figure 11.
9. Course Assessment of Federal Wildland Fire Occurrence Data, T.J. Brown et al., Climate, Ecosystem and Fire Applications Report 02-04, Desert Research Institute, University of Nevada, Reno, NV, 31 pp.
10. Watershed Management Council (non-profit), Watershed Management Council Networker, Winter 2000, Vol 9 No. 1, "Studies of Post-Fire Erosion in the Colorado Front Range Benefit the Upper South Platte Watershed Protection and Restoration Project, D. Martin, USGS.
11. “Forest Fires," Microsoft® Encarta® Online Encyclopedia 2005
12. http://www.mooselake-mn.com/Depot/
13. Economic Statistics for NOAA, May 2005
14. FARSITE Weather Streams from the NWS IFPS System, Gibson and Gorski, 5th Symposium on Fire and Forest Meteorology, 11-15 January 2004, Seattle, WA, American Meteorological Society, Boston, MA.
15. http://www.nbc4.tv/news/2583516/detail.html
16. http://www.ispe.arizona.edu/climas/conferences/NASW/west05/NSAWwestproceedings.pdf - Figure 1